Frictional properties of subduction zone input material from the erosive continental margin offshore Costa Rica (IODP expeditions 334 and 344)

Robert M. Kurzawski[1], Michael Stipp[1], André Niemeijer[2], Christopher J. Spiers[2], Jan H. Behrmann[1]

[1]*Department of Marine Geodynamics, GEOMAR Helmholtz Centre for Ocean Research, Wischhofstr. 1-3, D-24148 Kiel*
[2]*HPT Laboratory, Faculty of Geosciences, Utrecht University, Budapestlaan 4, NL-3584 Utrecht*

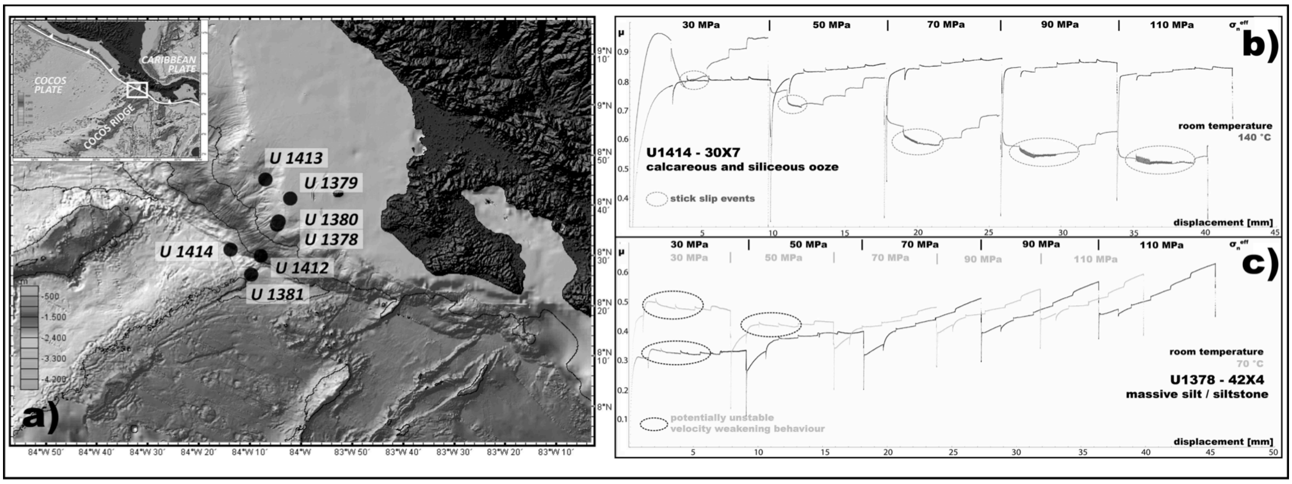

Fig. 1: (a) Bathymetric map of the CRISP area offshore Osa Peninsula with indicated drilling sites and tectonic overview inset map. (b,c) Evolution of friction with shear displacement during velocity-stepping experiments at different temperatures on (b) calcareous ooze from the incoming plate (IODP site U1414) and (c) clayey silt from the upper plate (U1378). At each applied effective normal stress velocity is stepped in the following order: 10-1-3-10-30-100 µm/s.

The **C**osta **Ri**ca **S**eismogenesis **P**roject (CRISP) investigates processes involved into the genesis of megathrust earthquakes and tsunamis at erosive active continental margins. Subduction erosion, i.e. the basal tectonic removal of overriding plate material occurs along the entire Middle America Trench (MAT), where the oceanic Cocos plate is subducted beneath the continental Caribbean plate. The incoming plate's topography exhibits considerable lateral variations affecting the overall geometry, thermal structure and seismicity pattern of the plate boundary interface. The Costa Rica segment of the MAT is the locus of increased tectonic erosion due to the subduction of the Cocos Ridge (Fig. 1a). This extensive topographic high originates from Galapagos hotspot volcanism and is oriented approximately perpendicular to the trench. Cocos Ridge subduction causes a steepening of the geothermal gradient and results in a shift in seismicity towards shallower levels equivalent to lower normal stresses.

Here we report on velocity stepping experiments performed on simulated fault gouges prepared from natural samples. Seven samples from 4 different CRISP drilling sites (U1378, U1379, U1412, U1414; Fig. 1a) were experimentally deformed in a hydrothermal rotary shear apparatus. Experimental conditions were defined to suitably cover the expected conditions at the CRISP updip limit of seismogenesis in approximately 5-6 km depth. Several temperature and effective normal stress combinations were explored to simulate the increasing geothermal gradient towards the Cocos Ridge. First results indicate important differences in the frictional behaviour of different sediments. Calcareous ooze from the incoming plate is frictionally strong at room temperature and exhibits a "normal stress weakening" and unstable slip (i.e. "stick-slip" events) at 140 °C (Fig. 1b). Clayey silt from the forearc of the overriding plate shows potentially unstable (i.e. velocity weakening) behaviour at low effective normal stress independent of investigated temperatures (Fig. 1c). As the active margin off Costa Rica changed repeatedly from accretion to tectonic erosion, it can be assumed that both incoming plate and forearc sediments are incorporated into the subduction channel and essentially affect seismogenesis and rupture propagation. Based on our experiments the shift in seismicity in the vicinity of the Cocos Ridge might be explained by a temperature-controlled change in frictional behaviour without mineral transformations, e.g. the smectite – illite transition.

References

Niemeijer, A.R., Spiers, C.J. and Peach, C.J. (2008). Tectonophysics, 460, 288-303.